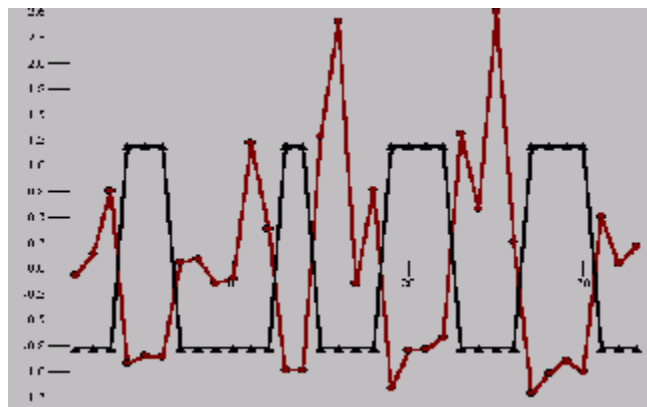


## Forecasting Weekly Beer Sales

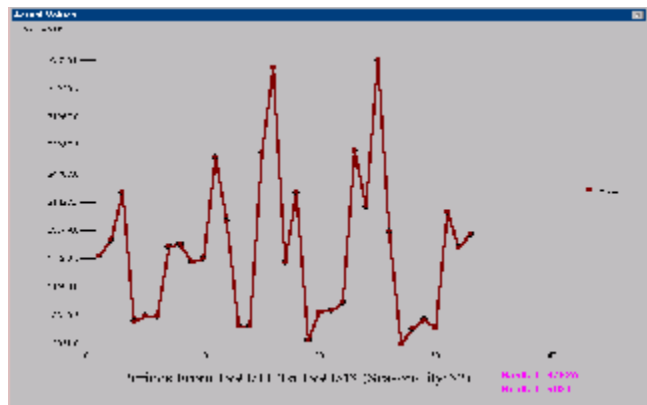
A case study of how Autobox is currently used to analyze a heavily promoted product.

This case study develops the relationship of price and volume while taking into account the effects of holidays and unusual activity on weekly beer sales.

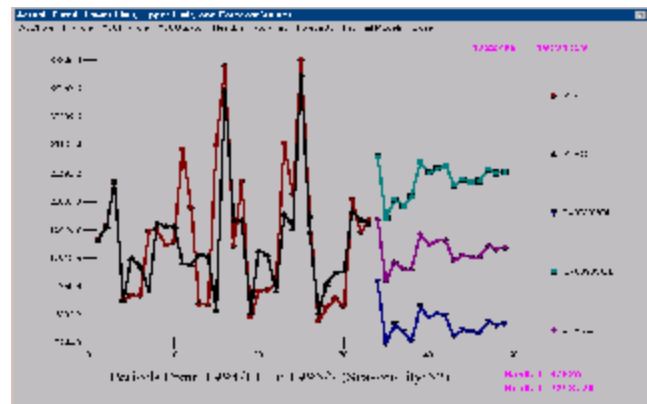
When the distributor lowers his price, the customer reacts. This relocation of demand is a boon for forecasters and for statistical models as the reaction is predictable and consistent. **VOL SALES** are in **RED** while **PRICE** is in **BLACK**. Note the persistence in the response of sales to price.



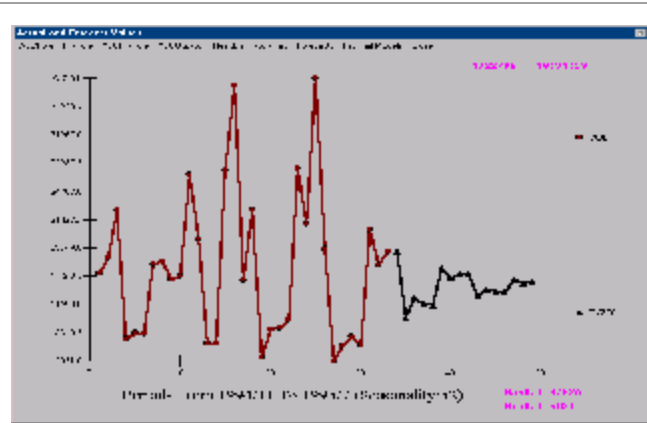
Weekly beer sales for the period 1994/11 through 1994/43 illustrates what the statistical problem is and what the business problem is. Consider a simple approach to predicting this series and the implications.



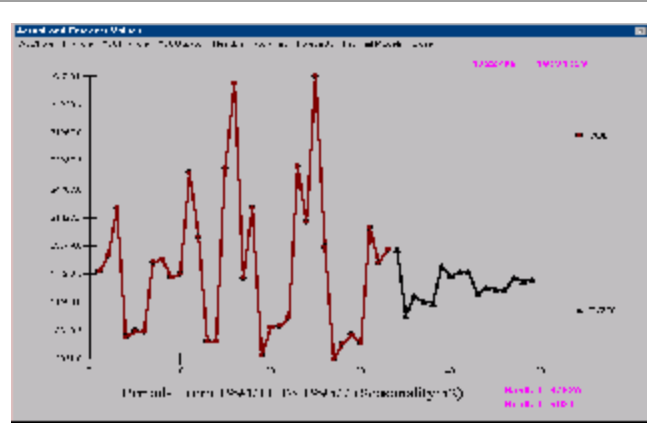
The univariate, i.e. auto-projective model is based on the relationship between successive observations. A four period relationship is identified and used to make one period out predictions, the fit, and ultimately a forecast for the next 16 periods ( week 44 through week 7 of 1995 )



Simplifying the graph, we have the historical values and the predicted values. Note that the forecasts don't have the deep "swings" that the actual values have and furthermore don't have the same "bunching together" appearance of the actual historical values.



Univariate models use the past of the series as a proxy for the omitted cause variable(s). In this case, the genuine dissatisfaction with the forecast reflects the inadequacy of a "rear-window" approach. One of the omitted variables is Price. Price is a lever to create and to dislocate sales from one period to another. This dislocation effect creates havoc for univariate modelers.



An examination of an ARIMA model, reveals two unusual values or outliers. The first unusual value occurs at week 35(8/29/94) while the second unusual value occurred at week 26(6/27/94). Note that the model identifies a negative response (inverse) to sales 4 weeks ago. What this means is that if sales were high 4 weeks ago,

**EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\EQUATION.123]**

File Edit Fonts Window

$$Y(T) = 0.32264E+09$$

$$+ [X1(T)] [(+ 19318. )]$$

$$+ [X2(T)] [(+ 23339. )]$$

$$+ [(1+ 0.573B** 4)]** -1 [A(T)]$$

Analysis for Variable Y = VOL

as : NEWLY IDENTIFIED VARIABLE X1 = I~AP0025 1994/ 8/29 PULSE

: NEWLY IDENTIFIED VARIABLE X2 = I~AP0016 1994/ 6/27 PULSE

As a Simple Weighted Average of the Past:

	CONSTANT	
	21742.1	

	LAG	WEIGHT	OBSERVATION	PRODUCT	SUM
VOL	4	-.572773	6904.00	-3954.43	-3954.43

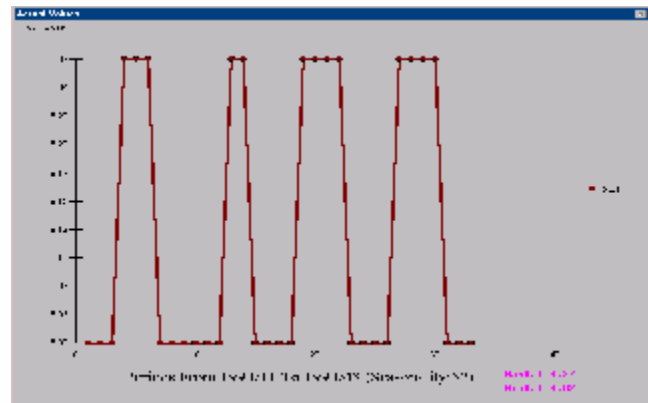
FORECAST FOR THE NEXT PERIOD= 17787.6

5:40:05 PM User Status = Advanced 4 1 31 db: WWW Series: VOL

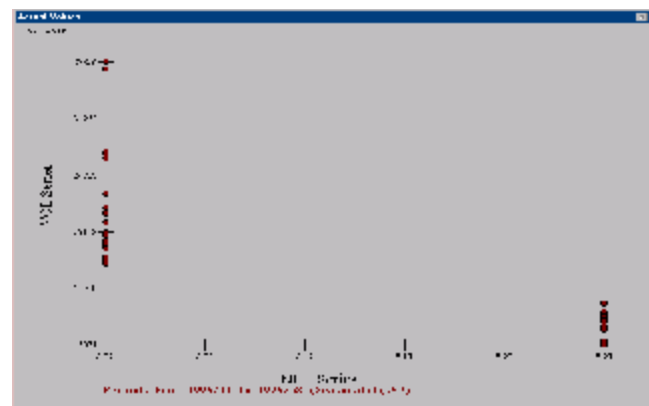
Start C:\TRASH MS-DOS... Graphics... EDITO... Netscap... Netscap... L

current sales will be low. The forecast equation is  $21,742$  multiplied by  $57\%$  of sales 4 weeks ago. Note that the omitted variable Price has a 4 week profile.

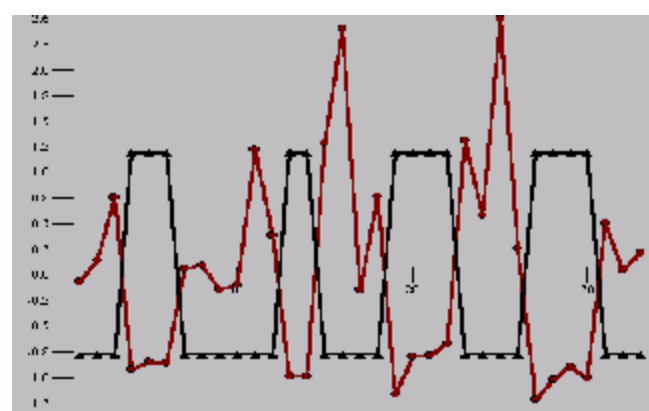
This equation arises because Price is varied in such a way that sales increase with lower price (the low values are low price) and drop back when price is restored to its normal level. The promotion calendar has a 4 week length thus the appearance and inducement of a 4 period "seasonality". If sales were low, that is "off promo" 4 weeks ago then sales will be high this week because we are "on promo".



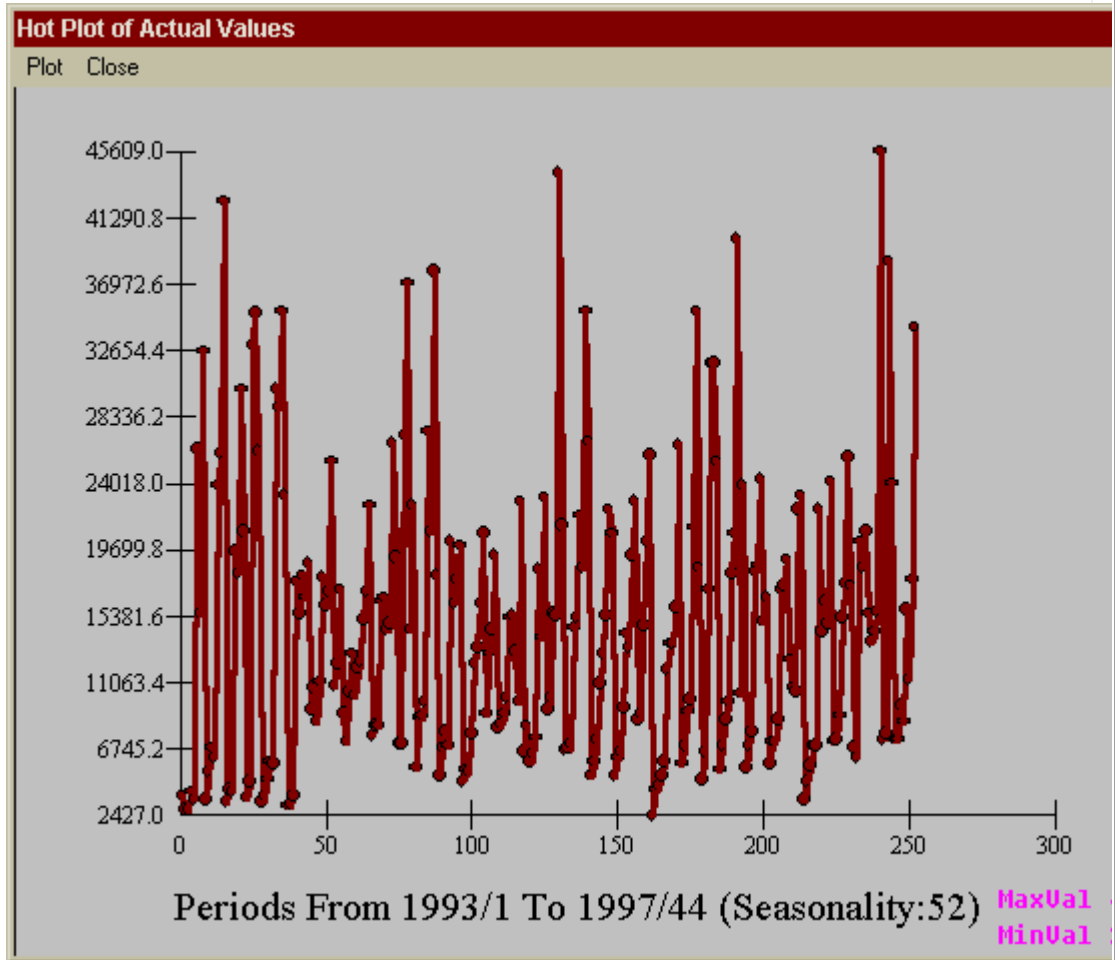
The dependence of Sales on Price can be seen in a scatterplot showing how Sales increase when the Price is low and Sales decrease at standard pricing. Notice how all the points reflecting low price reflect high volume while all the points for high price indicate low volume.



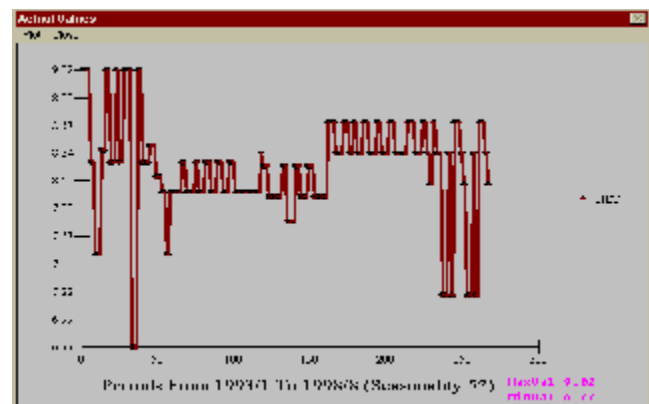
The dependence of Sales on Price can be seen even clearer in this line plot of VOL and PRICE against time ( 33 month period 1994/11 through 1994/43)



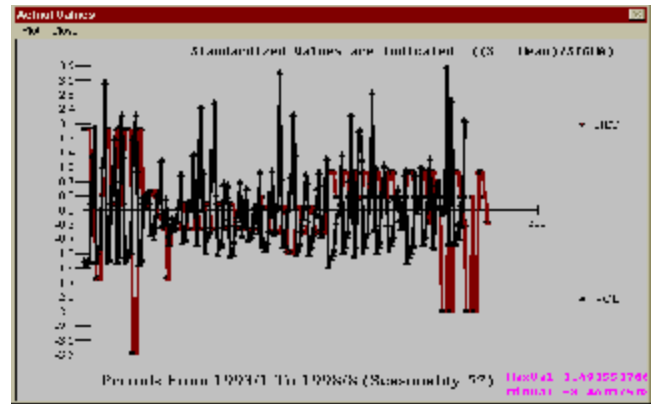
We now will extend our model to include Price and some Holiday variables to explain unusual and predictable "spikes" due to increase consumption around Labor Day, July 4th, Memorial Day and of course St. Patrick's Day. We show here sales for the period 1993/1 through 1997/44.



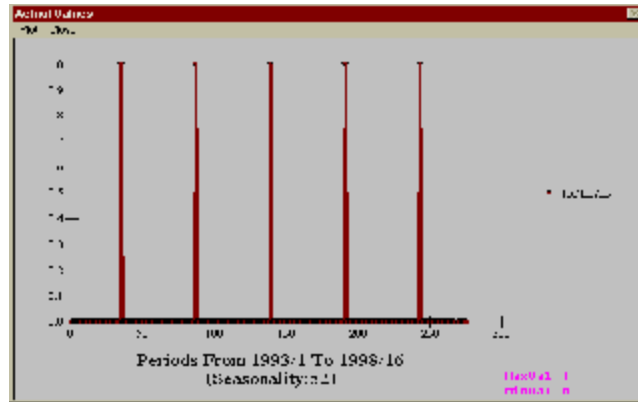
First, we show Price on a weekly basis for the period. Notice that from time to time major changes are made in the "Base Price" i.e. the nominal off promo price.



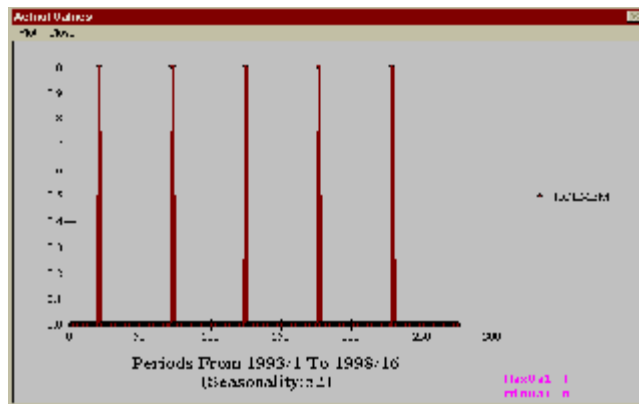
If we view both Sales and Price together the graph is somewhat busy do to the length of the series.  
When we restricted ourselves to a 33 week period the picture was very clear.



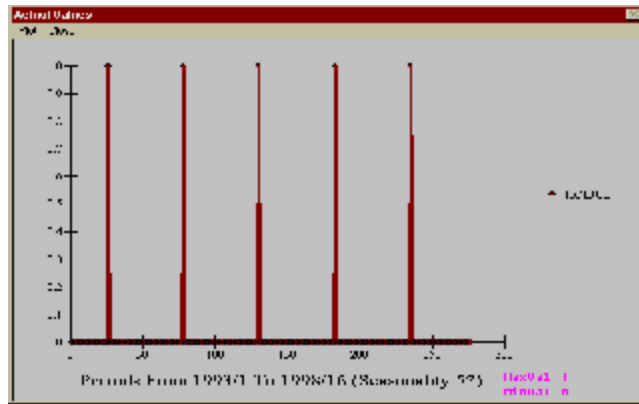
We now show the July 4th Day variable.



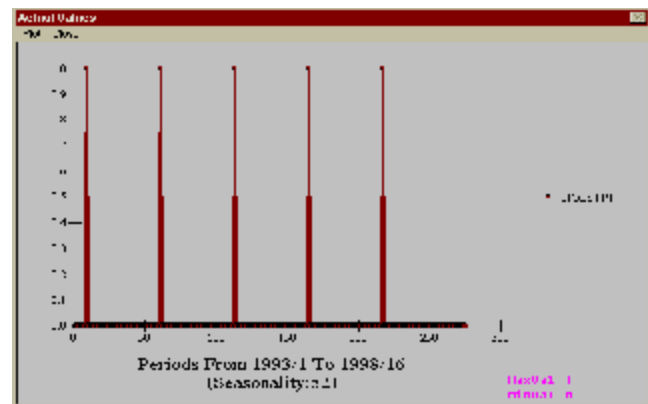
We now show the Labor Day variable.



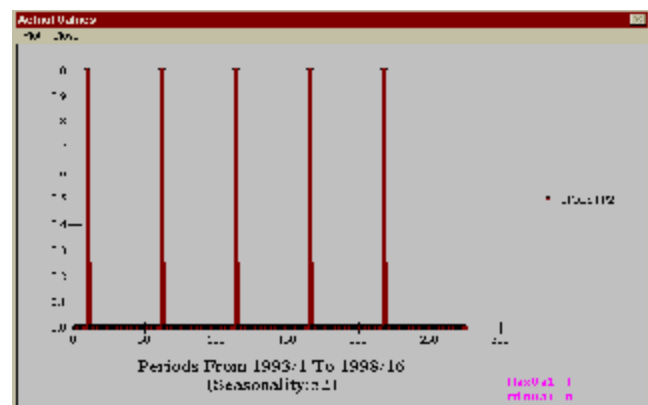
We now show the Memorial Day variable.



We now show the first St. Patrick's Day variable. The St. Patrick's Day effect was broken into three to reflect different responses depending upon where it fell in the work week.

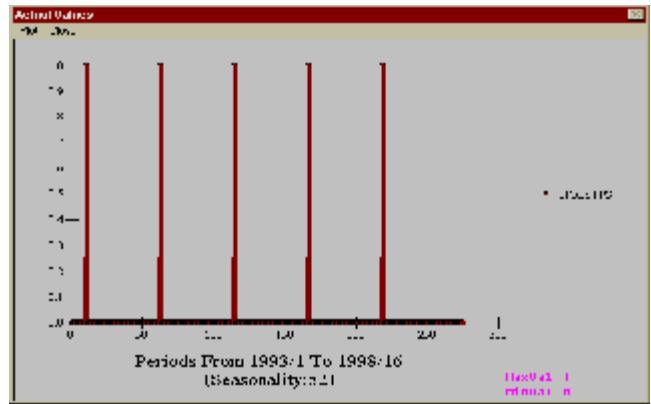


We now show the second St. Patrick's Day variable.

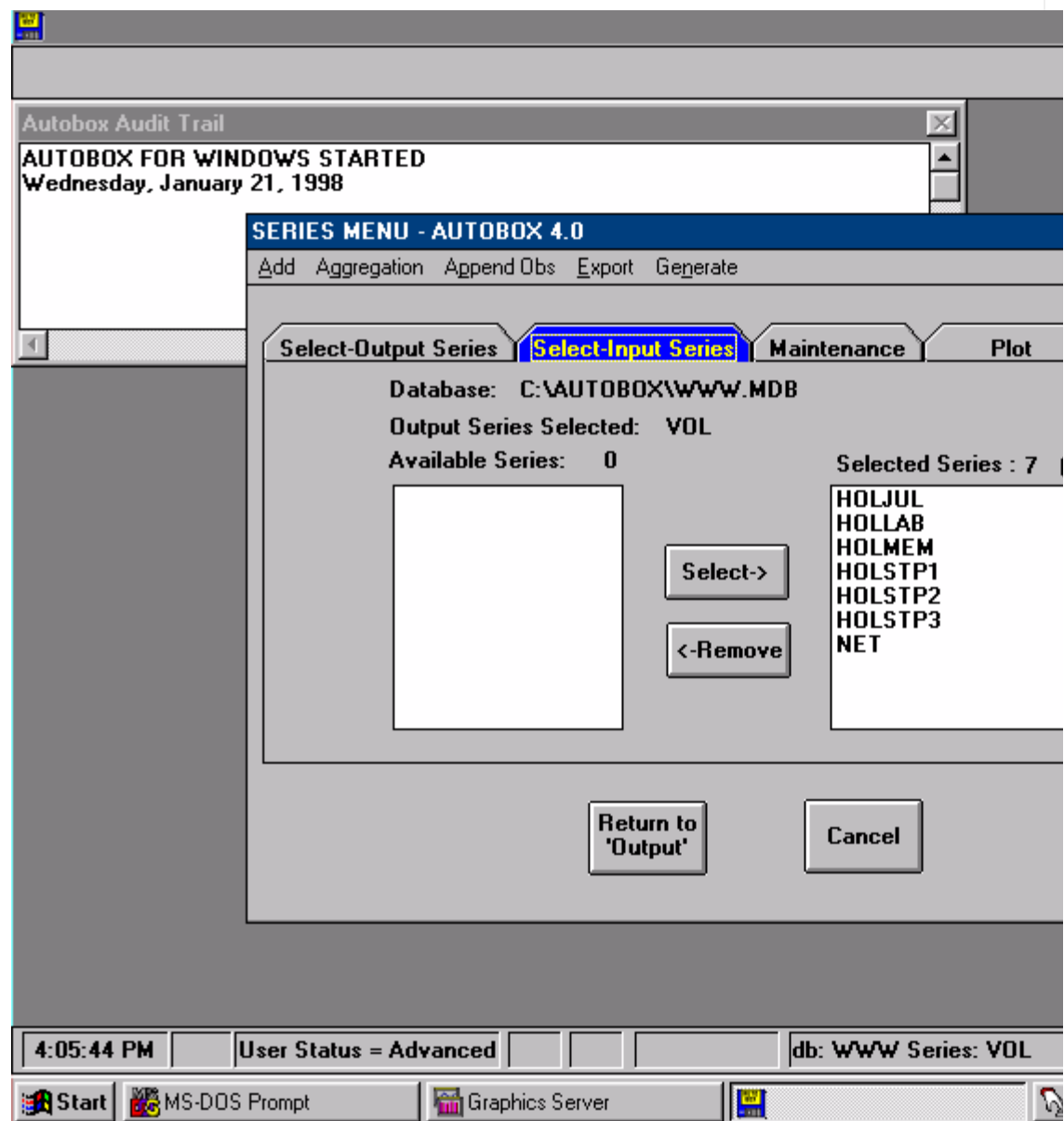




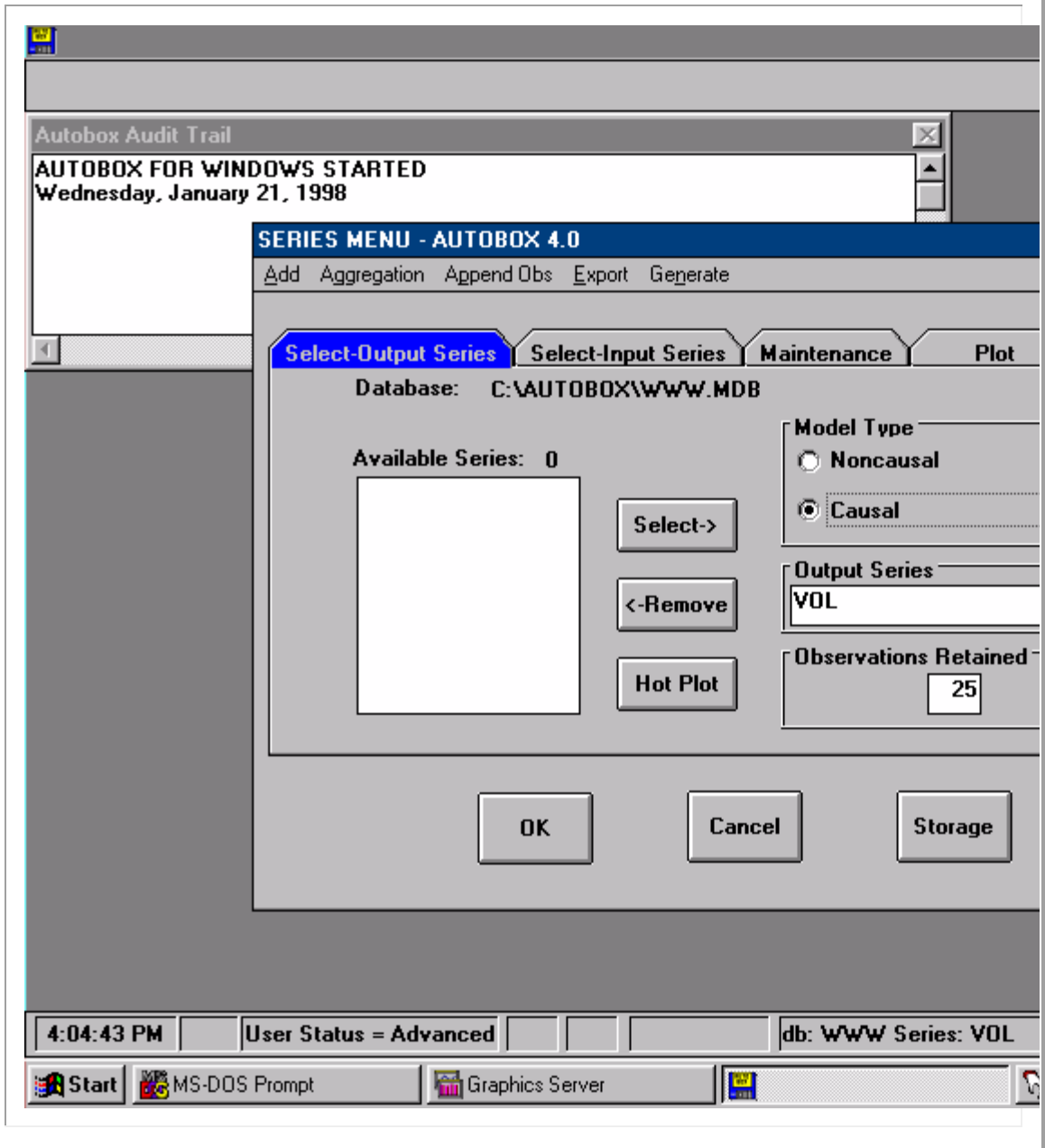
We now show the third St. Patrick's Day variable.



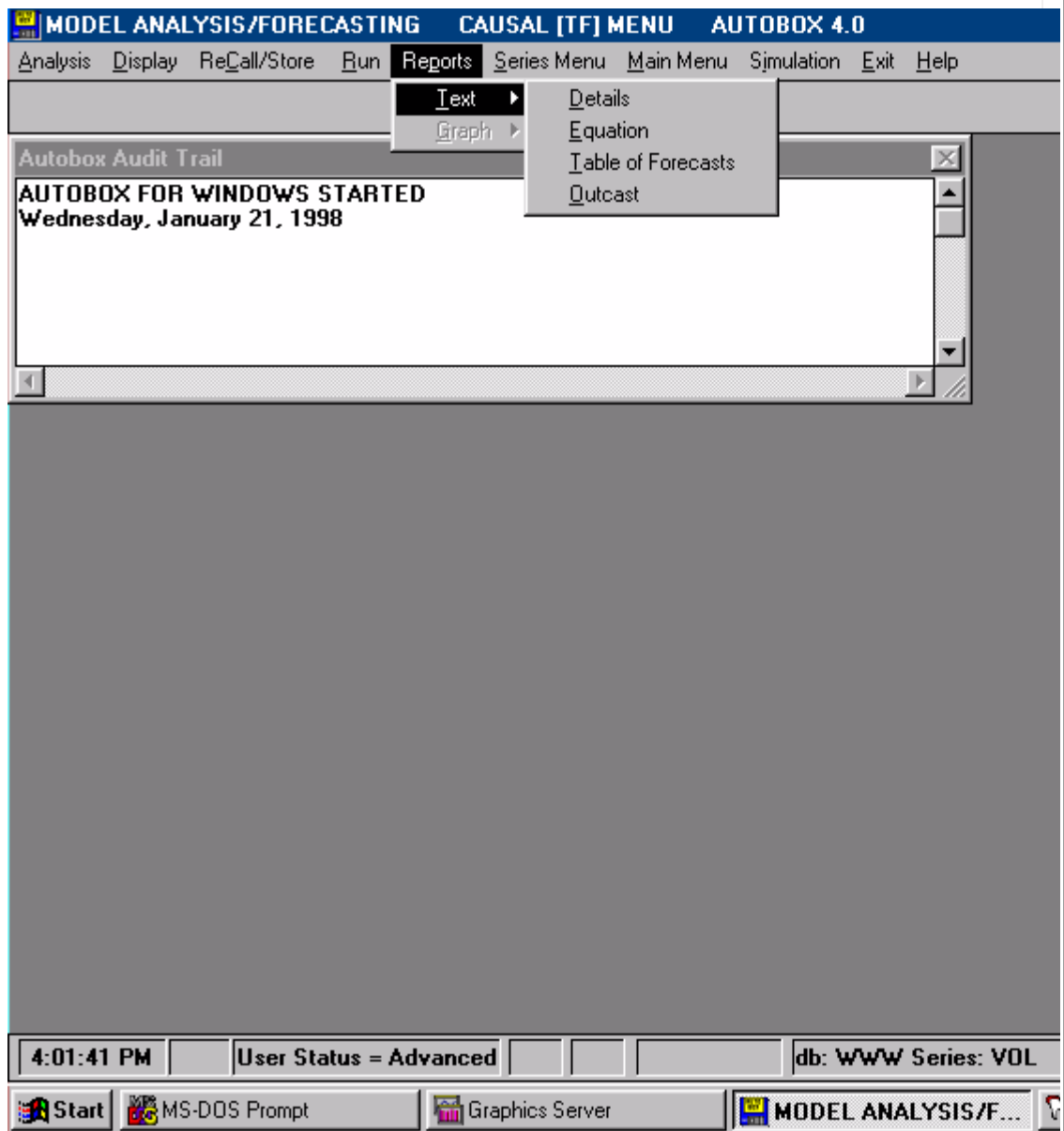
We use AUTO BOX to select the input series that will be evaluated in constructing a model for Sales.



We will withhold the most recent 25 values and prepare a 16 week ahead forecast from each origin. Thus only one model and one set of parameters will be developed. The forecast will be made and an assessment will be developed measuring model performance.



After execution, we examine the "OUTCAST" analysis.



The actual forecasts made from each origin are displayed.

**EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\OUTCAST.123]**

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TABLE 0 :ACTUALITY & FORECASTS AT DIFFERENT FORECAST ORIGINS FOR VOL

ACTUAL	0.175E+05	0.257E+05	0.174E+05	0.686E+04	0.620E+04	0.202E+05	0.186E+05	0.
ORIGIN	1997/ 20	1997/ 21	1997/ 22	1997/ 23	1997/ 24	1997/ 25	1997/ 26	19
1997/ 19	0.167E+05	0.317E+05	0.151E+05	0.810E+04	0.897E+04	0.140E+05	0.275E+05	0.
1997/ 20		0.318E+05	0.152E+05	0.797E+04	0.891E+04	0.140E+05	0.275E+05	0.
1997/ 21			0.137E+05	0.762E+04	0.100E+05	0.146E+05	0.277E+05	0.
1997/ 22				0.848E+04	0.102E+05	0.139E+05	0.274E+05	0.
1997/ 23					0.986E+04	0.138E+05	0.277E+05	0.
1997/ 24						0.129E+05	0.275E+05	0.
1997/ 25							0.292E+05	0.
1997/ 26								0.
1997/ 27								
1997/ 28								
1997/ 29								
1997/ 30								
1997/ 31								

4:01:56 PM User Status = Advanced 1 1 107 db: WWW Series: VOL


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TABLE  
1.

EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\OUTCAST.123]

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TABLE 1 : FORECAST ACCURACY STATISTICS AT VARIOUS LEAD TIMES

FORECAST LEAD TIME	MEAN DEVIATION (BIAS) = (A-F)/n	MEAN % ERROR [(A-F)/A]/n	MEAN ABSOLUTE DEVIATION A-F /n	MEAN ABSOLUTE % ERROR [ (A-F)/A ]/n
1	0.535973E+03	-.142987E+02	0.595654E+04	0.382176E+02
2	0.462414E+03	-.136732E+02	0.576110E+04	0.354999E+02
3	0.723939E+03	-.126562E+02	0.556981E+04	0.345181E+02
4	0.684896E+03	-.122962E+02	0.564313E+04	0.328290E+02
5	0.797619E+03	-.108698E+02	0.565565E+04	0.319488E+02
6	0.981354E+03	-.937847E+01	0.578939E+04	0.314204E+02
7	0.700213E+03	-.111930E+02	0.575046E+04	0.311835E+02
8	0.123083E+04	-.935179E+01	0.556438E+04	0.304550E+02
9	0.176681E+04	-.764025E+01	0.542432E+04	0.299271E+02
10	0.159572E+04	-.994235E+01	0.547280E+04	0.299330E+02
11	0.182649E+04	-.971119E+01	0.572648E+04	0.311109E+02
12	0.208972E+04	-.946579E+01	0.600726E+04	0.323744E+02
13	0.233791E+04	-.963389E+01	0.638115E+04	0.343061E+02
14	0.170241E+03	-.156317E+02	0.455250E+04	0.319945E+02
15	0.820077E+03	-.845790E+01	0.433230E+04	0.263159E+02
16	0.166084E+04	0.488302E+00	0.400524E+04	0.191467E+02

11:29:53 AM User Status = Advanced 87 1 116 db: WWW Series: VOL

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A summarization of the forecast errors leads to TABLE 2.

EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\OUTCAST.123]

File Edit Fonts Window

TABLE 2 : FORECAST ACCURACY STATISTICS AT VARIOUS LEAD TIMES

FORECAST LEAD TIME	VARIANCE (PRECISION) = [(A-F) - 1] / n	BIAS SQUARED (RELIABILITY)	MEAN SQUARE % ERR. (ACCURACY) ((A-F)/A) / n	RELATIVE ABSOLUTE ERROR (A-F) / (A-N)
1	0.755616E+08	0.287267E+06	0.286635E+00	0.661086E+00
2	0.730433E+08	0.213826E+06	0.211989E+00	0.476587E+00
3	0.714043E+08	0.524087E+06	0.192248E+00	0.549298E+00
4	0.761541E+08	0.469082E+06	0.180529E+00	0.508302E+00
5	0.756408E+08	0.636196E+06	0.171721E+00	0.503513E+00
6	0.789622E+08	0.963055E+06	0.169916E+00	0.488508E+00
7	0.805622E+08	0.490298E+06	0.170363E+00	0.452653E+00
8	0.799861E+08	0.151494E+07	0.172851E+00	0.455348E+00
9	0.796989E+08	0.312160E+07	0.175192E+00	0.552587E+00
10	0.841482E+08	0.254634E+07	0.180830E+00	0.510278E+00
11	0.890427E+08	0.333606E+07	0.191887E+00	0.517316E+00
12	0.945707E+08	0.436694E+07	0.204396E+00	0.503666E+00
13	0.100951E+09	0.546581E+07	0.219670E+00	0.530101E+00
14	0.483682E+08	0.289819E+05	0.205951E+00	0.591727E+00
15	0.476723E+08	0.672527E+06	0.143212E+00	0.524492E+00
16	0.446485E+08	0.275839E+07	0.616107E-01	0.414466E+00

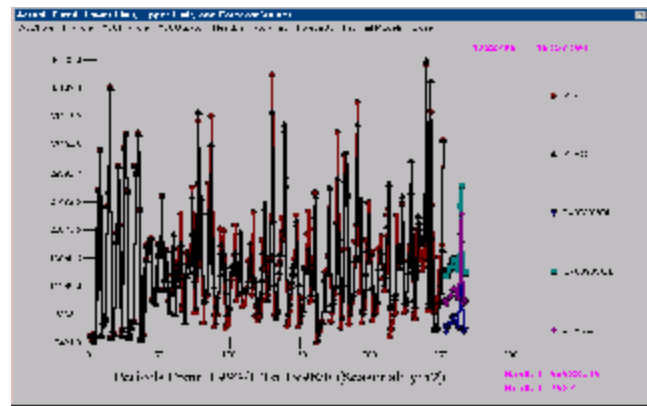
11:36:23 AM User Status = Advanced 111 69 121 db: WWW Series: VOL

Start MS-D... Nets... Grap... EDI... Lankf... Conn... Nets... Nets...

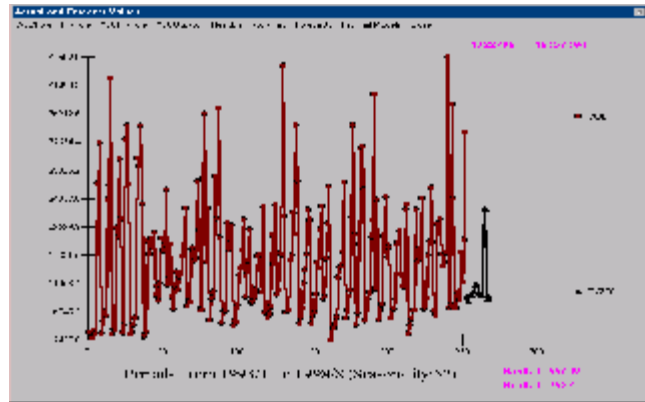
A side bar on measuring forecast accuracy



Convinced that this approach was giving better forecasts than all other known alternatives we remodel using all of the data. Here we show the actual, fit and forecast. the Plotcast option to view the results.



Now just the actual and the forecasts are shown.





Exploring the equation we find that the following variables were included in the final model.

The screenshot shows the EDITOR MENU - AUTOBOX 4.0 interface. The title bar indicates the file path is C:\AUTOBOX\EQUATION.123. The menu bar includes File, Edit, Fonts, and Window. The toolbar contains icons for file operations. The main window displays a list of variables and their coefficients, along with a mathematical expression for Y(T). The status bar at the bottom shows the time as 7:58:14 PM, user status as Advanced, and other system information.

**EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\EQUATION.123]**

File Edit Fonts Window

Y(T) = 0.75083E+09  
 +[X1(T)] [(+ 13532. )]  
 +[X2(T)] [(+ 20261. )]  
 +[X3(T)] [(+ 10907. )]  
 +[X4(T)] [(+ 4631.6 )]  
 +[X5(T)] [(- 12835. )]  
 +[X6(T)] [(+ 26394. )]  
 +[X7(T)] [(+ 24601. )]  
 +[X8(T)] [(+ 15067. )]  
 +[X 9(T)] [(+ 12468. )]  
 +[X10(T)] [(+ 11057. )]  
 +[X11(T)] [(+ 5211.5 )]  
 +[X12(T)] [(+ 13263. )]  
 +[X13(T)] [(+ 12085. )]  
 +[X14(T)] [(+ 11702. )]  
 +[X15(T)] [(- 6784.5 )]  
 +[X16(T)] [(+ 12792. )]  
 +[X17(T)] [(+ 9443.2 )]  
 +[X18(T)] [(+ 9663.2 )]  
 +[X19(T)] [(+ 11550. )]  
 +[X20(T)] [(+ 6506.6 )]  
 + [(1- 0.487B\*\* 1+ 0.143B\*\* 2)(1- 0.201B\*\* 52)  
 (1+ 0.158B\*\* 4)]\*\* -1 [A(T)]

7:58:14 PM User Status = Advanced 5 1 121 db: WWW Series: VOL

Start MS-DOS Prompt Graphics Server EDITOR M... Lankford Scre... MS-DOS Prom

EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\EQUATION.123]

File Edit Fonts Window



```
Y(T) = 0.75083E+09
      +[X1(T)][(+ 13532.  )]
      +[X2(T)][(+ 20261.  )]
      +[X3(T)][(+ 10907.  )]
      +[X4(T)][(+ 4631.6  )]
      +[X5(T)][(- 12835.  )]
      +[X6(T)][(+ 26394.  )]
      +[X7(T)][(+ 24601.  )]
      +[X8(T)][(+ 15067.  )]
      +[X 9(T)][(+ 12468.  )]
      +[X10(T)][(+ 11057.  )]
      +[X11(T)][(+ 5211.5  )]
      +[X12(T)][(+ 13263.  )]
      +[X13(T)][(+ 12085.  )]
      +[X14(T)][(+ 11702.  )]
      +[X15(T)][(- 6784.5  )]
      +[X16(T)][(+ 12792.  )]
      +[X17(T)][(+ 9443.2  )]
      +[X18(T)][(+ 9663.2  )]
      +[X19(T)][(+ 11550.  )]
      +[X20(T)][(+ 6506.6  )]
      + [(1- 0.487B** 1+ 0.143B** 2)(1- 0.201B** 52)
      (1+ 0.158B** 4)]** -1 [A(T)]
```

With  
coefficients ....

7:58:14 PM User Status = Advanced 5 1 121 db: WWW Series: VOL

Start MS-DOS Prompt Graphics Server EDITOR M... Lankford Scre... MS-DOS Pro

As before the forecast is a weighted sum of the past and future values of the input series.

**EDITOR MENU - AUTOBOX 4.0 - [C:\AUTOBOX\EQUATION.123]**

File Edit Fonts Window

	LAG	WEIGHT	OBSERVATION	PRODUCT	SUM
NET	0	-12835.4	8.09000	-103839.	-103839.
	1	6249.26	8.09000	50556.5	-53282.2
	2	-1840.90	8.09000	-14892.9	-68175.1
	4	-2027.38	8.34000	-16908.3	-85083.4
	5	987.079	8.59000	8479.01	-76604.4
	6	-290.773	8.59000	-2497.74	-79102.2
	52	2582.93	8.34000	21541.6	-57560.6
	53	-1257.56	8.34000	-10488.1	-68048.6
	54	370.452	8.34000	3089.57	-64959.1
	56	407.977	8.34000	3402.53	-61556.5
57	-198.634	8.59000	-1706.26	-63262.8	
58	58.5134	8.59000	502.630	-62760.2	
.....					
VOL	1	0.486875	34105.0	16604.9	-47403.1
	2	-.143423	17721.0	-2541.60	-49944.7
	4	-.157951	15791.0	-2494.21	-52438.9
	5	0.769026E-01	8501.00	653.749	-51785.1
	6	-.226539E-01	9573.00	-216.866	-52002.0
	52	0.201234	16595.0	3339.48	-48662.5
	53	-.979758E-01	14987.0	-1468.36	-50130.9
	54	0.288616E-01	24278.0	700.703	-49430.2
	56	0.317852E-01	18264.0	580.524	-48849.6
	57	-.154754E-01	7862.00	-121.668	-48971.3
58	0.455874E-02	7003.00	31.9248	-48939.4	
FORECAST FOR THE NEXT PERIOD=					21136.5

8:00:56 PM User Status = Advanced 86 23 103 db: WWW Series: VOL

The data.. HOLJUL,HOLLAB,HOLMEM,NET,VOL

